# Assessing the impact of the STEM Academy model on confidence in STEM in teachers and pupils

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## Abstract

*Many UK primary teachers currently lack confidence and skills in Science, Technology, Engineering and Maths (STEM) subjects to help deliver high quality experiences of STEM learning in the classroom that inspire and motivate pupils. There is evidence that primary teachers/probationers would benefit from further training in STEM subjects and that opportunities to engage with and work in partnership with experts in industry and academia may help develop teacher confidence in STEM. The Summer STEM Academy was the first in the UK to bring primary teachers (n=31) and senior pupils (age range 15-17 years) (n=39) into an academic environment aligned with industry and, through structured partnership working, assess the impact of this model on teacher and pupil confidence in and attitudes to STEM. Impact of the STEM Academy was assessed using validated questionnaires completed pre- and post- the event. The results indicate a significant reduction in primary teacher anxiety and increase in self-efficacy associated with improved confidence in STEM engagement and education. There was a significant improvement in pupil attitudes to science and technology and a positive trend in pupil confidence and engagement in STEM.*

**Keywords:** STEM, partnership working, transition, confidence

## Aim of the study

The aim of this study was to assess the impact of a university- and industry-led STEM Academy model of multi-level partnership working on teacher and pupil confidence in and attitudes to STEM.

## Background

The *UK STEM Education Landscape* report (Morgan *et al*, 2016) identified the importance of primary schools providing appropriate, accurate and inspiring STEM education to children from an early age, and ensuring that teachers responsible for science are appropriately trained even if they are not science specialists. Currently, only 5% of primary school teachers have a qualification at A-level or above in mathematics or science (Morgan *et al*, 2016), which may influence their willingness to engage in teaching STEM-related activities in the classroom. It is essential that primary teachers are confident and skilled in delivering STEM subjects and use motivational approaches to learning, especially with disadvantaged pupils (Rocard, 2017). Current programmes to develop STEM skills in primary teachers are limited in the amount of STEM that teachers experience and provision of opportunities to promote partnerships that would help address the lack of STEM confidence in student teachers. An intervention to assist primary student teachers in teaching science had difficulty showing any impact (Watters, 1994), indicating the importance of an appropriately organised programme to engage primary student teachers in STEM.

## Rationale

The STEM Academy was initiated in response to requests by primary student teachers for a programme of support and training in STEM before entering their probationary year (Ritchie *et al*, 2018). The Summer STEM Academy model was the first in the UK to address the current lack of STEM skills and confidence in primary student teachers, using structured partnerships to develop teacher and pupil confidence and skills in STEM to inspire younger and disadvantaged pupils. This innovative approach to learning and teaching, involving sustainable and structured partnerships (Education Scotland, 2017) between Initial

Teacher Education (ITE) or Initial Teacher Training (ITT) providers, schools, industry and higher education, may help contextualise STEM learning (Ritchie *et al*, 2018), raise awareness of careers involving STEM subjects (Education Scotland, 2015), support transition, further develop meaningful partnerships between schools and industry/academia and promote enquiry-based science learning. This has been shown to help raise attainment (Abdi, 2014) by providing an inspirational approach to science learning (Rocard, 2017; Martina *et al*, 2016), making science interesting, and developing pupils' critical thinking skills (Seraphin *et al*, 2012). There is evidence that partnerships (Ritchie, 2018) enhance student teacher and pupil confidence and attainment in STEM (Parliamentary Briefing, 2017). Increased skills and confidence of student teachers and pupils will support progression and skills development of disadvantaged pupils. The STEM Academy was also designed to increase student teacher science knowledge and insight into good practice and assessment in science, key aspects of ITT/ITE recently highlighted as requiring action (Ritchie *et al*, 2018; Wellcome Trust, 2017). Enquiry-based science education incorporates pedagogical approaches to learning and teaching that can also increase pupil engagement and encourage metacognition, collaborative learning, peer tutoring and feedback (Seraphin *et al*, 2012), which may increase engagement of disadvantaged pupils (Rocard, 2017; EEF toolkit, 2018). The need for primary student teachers to receive support in STEM is highlighted by Kurup *at al* (2019).

## Design and implementation of the STEM Academy model

The Summer STEM Academy was designed to provide training in STEM to pre-probationer primary teachers and senior secondary pupils over two days. Approximately 25 pupils (aged 15 to 17 years) and 25 pre-probationer primary teachers participated at each STEM Academy, in addition to academic and industrial experts. Workshops related directly to industry and university research and activity providers' and STEM Ambassadors' areas of expertise. A pilot STEM Academy took place in 2018. Impact of the 2018 model on pupils and teachers was assessed using validated questionnaires and, due to the highly positive impact found, two STEM Academies took place at two separate locations in 2019. The format and programme for all the STEM Academies was consistent over the two days. A limitation of the initial STEM Academy was the lack of ethical approval, which reduced the numbers from whom data could be collected for publication. A further limitation of the STEM Academy was accessibility of the workshops in a UK setting. This was addressed whereby workshops were chosen to ensure that they were available to schools across the UK, as far as possible. A strength of the STEM Academy was due to the group design, where secondary pupils explained the science associated with each workshop to the primary student teachers, therefore helping to improve their confidence in delivering STEM in a primary classroom. This built upon another key feature of the STEM Academy model, namely the co-creation of a STEM-based activity that secondary pupils could deliver in a primary setting.

## Summary of the STEM Academy Programme

Each Summer STEM Academy brought student primary probationers and senior pupils together with STEM researchers from academia and industry. Activities were designed to promote confidence in STEM delivery and understanding, including the design principles of high quality and curriculum-linked STEM activities. Participant groups consisted of 2-3 primary probationer teachers and 2-3 senior pupils. During Day One, groups undertook team-building activities in engineering (an innovative challenge – developing resources for the disabled), forensic science and also molecule hunts for bio-molecules and everyday molecules, followed by a co-creation activity involving speed dating with industry, including STEM Ambassadors and academia. There was an evening social event consisting of a science ceilidh relating scientific processes to the dance floor. During Day Two, groups participated in a variety of STEM-related workshops led by researchers and industries, providing a variety of contexts and careers involving STEM. These included Solar Energy, Astrobiology, F1 in Schools Car Design, Astronomy with Space Research, Science Communication, Molecule Building, Air Race Challenge, Genetics and Coding. After lunch, participants undertook industrial experience within a Science Innovation Centre (Biocity Scotland) and, in collaboration with researchers, co-created activities for delivery to a variety of audiences. The Science

Innovation Centre could easily consist of a visit to a local industry. Many workshops could be replicated in England, Ireland and Wales, as they are available online and via STEM Ambassadors. Combined expertise ensured that activities and resources developed practical and critical thinking skills, and skills in educational pedagogy. Activities and resources developed in the Academy could be further developed and disseminated by participants, with one activity from each Academy being chosen as an exemplar for the following year. Pupil participants could further participate in a Personal Recognition in Academic and Industrial STEM Education (PRAiSE) award. To achieve this award, secondary schools had to demonstrate their involvement/collaboration with at least one partner organisation, e.g. industry or academia, including STEM Ambassadors and evidence of pedagogical approaches that promoted enquiry-based learning and metacognitive approaches to learning through engagement with primary schools and school communities. This engagement with primary schools was a key outcome of the STEM Academy. Secondary pupils delivered workshops that had been co-created during the STEM Academy to primary schools during follow-up to the STEM Academy. Furthermore, primary student teachers had access to partners who could assist with delivery of STEM-based activities within a primary setting.

During follow-up to the STEM Academy, each primary probationer and each participating secondary school were provided with access to presentations, workshops, activities and resources. Primary probationer teachers and secondary schools could also request support for development of projects within primary settings demonstrating progression through the primary and secondary science curriculum.

## Method for evaluation of the STEM Academy

All delegates attending each STEM Academy completed a pre-event validated evaluation questionnaire (van Aalderen-Smeets *et al*, 2012; van Aalderen-Smeets, 2013) during registration at the start of the event and before attending any lectures or workshops. Questionnaires were granted ethical approval by the University ethics committee. Delegates also completed a post-evaluation questionnaire, which contained the same questions and included additional questions about the value and relevance of the STEM Academy and suggestions for future events. The evaluation questionnaire questions assessed confidence in science and technology and opinions/attitudes to science and technology. Questions associated with confidence were split into a variety of categories associated with key components of confidence, i.e. self-efficacy, context dependency, anxiety, enjoyment, relevance, and difficulty.

Each questionnaire question used a Likert scale, seeking agreement or disagreement with a statement, on a scale from 1 to 5:

1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree.

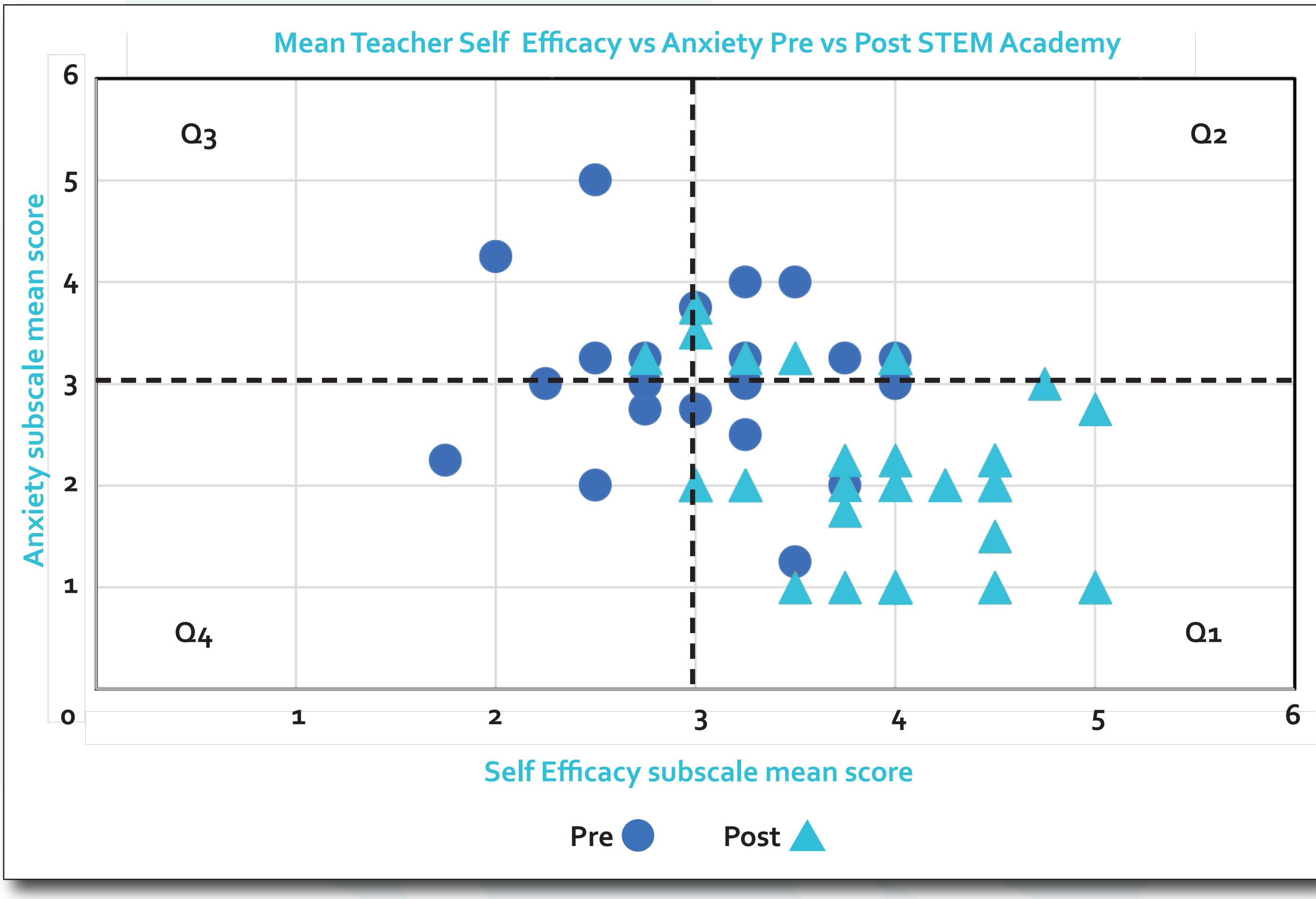
Completed evaluation questionnaires were collected and only responses from completed pre- and post-event evaluation forms were used for analysis of the data.

Data were paired for each participant. Mean values were calculated for each delegate's pre- and post-response in attitudes and each confidence category, i.e. self-efficacy, (perceived) context dependency, anxiety, enjoyment, relevance, and difficulty. Mean values pre- and post- were subsequently used to create scatter plots of anxiety vs self-efficacy, anxiety vs enjoyment and (perceived) context dependency vs self-efficacy.

## Results

During the three STEM Academies that took place, probationer pre-service primary teachers (n = 83) and senior pupils (n = 76, age range 15-17 years) from a variety of secondary schools situated within 14 local authorities across Scotland participated in the event.

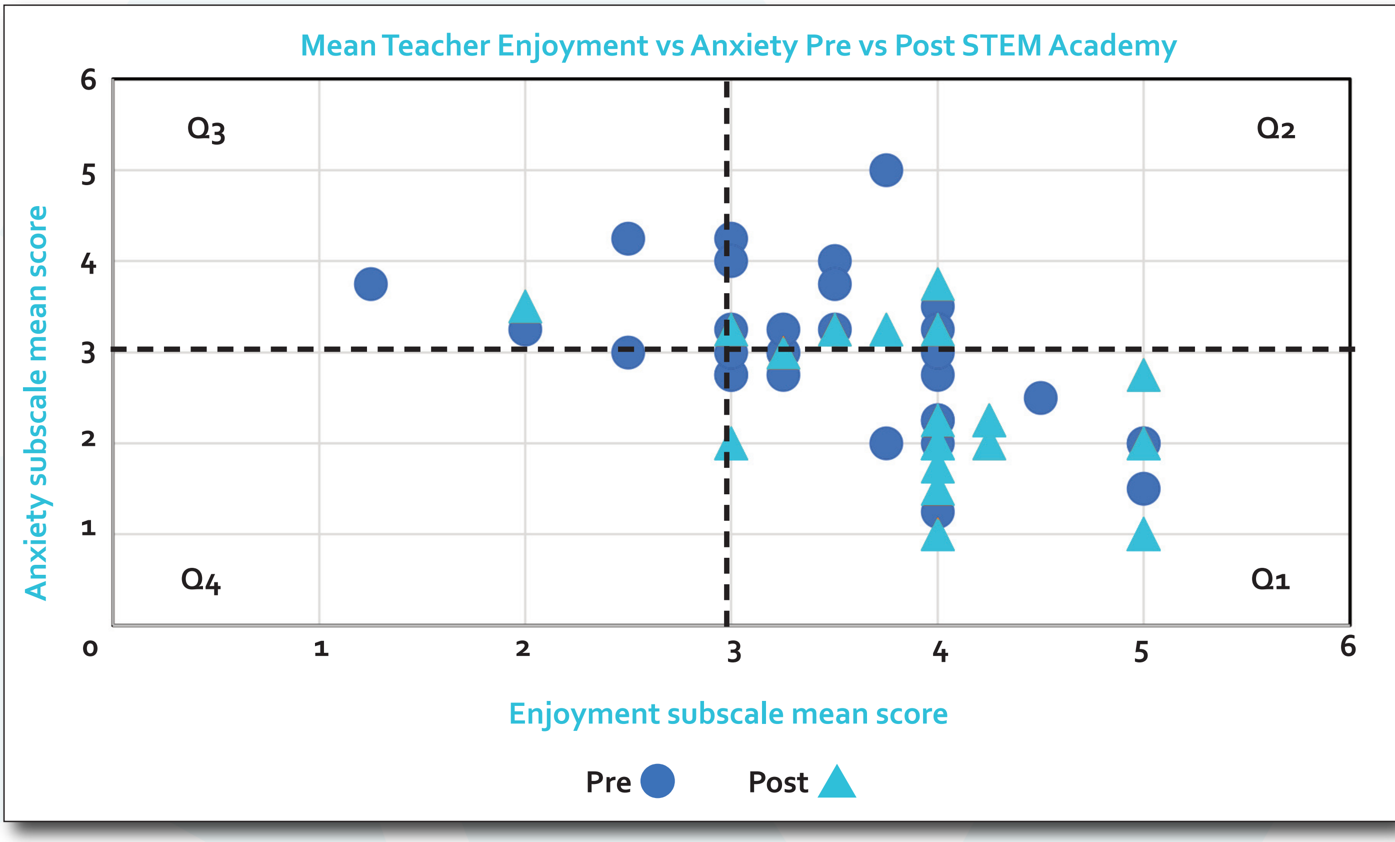
*Results Panel A*




Self-efficacy vs Anxiety quadrant allocation – teachers (n=31).

| Quadrant | Pre-STEM Academy | Percent of total Pre-STEM Academy | Post-STEM Academy | Percent of total Post-STEM Academy |
|---|---|---|---|---|
| 1 | **7** | 22.6 | **23** | 74.2 |
| 2 | **7** | 22.6 | **4** | 12.9 |
| 3 | **11** | 35.5 | **3** | 9.7 |
| 4 | **6** | 19.4 | **1** | 3.2 |

*Results Panel B*




**Enjoyment vs Anxiety quadrant allocation – teachers (n=31).**

| Quadrant | Pre-STEM Academy | Percent of total Pre-STEM Academy | Post-STEM Academy | Percent of total Post-STEM Academy |
|---|---|---|---|---|
| 1 | 11 | 35.5 | 22 | 68.8 |
| 2 | 10 | 32.3 | 5 | 15.6 |
| 3 | 8 | 25.8 | 2 | 6.3 |
| 4 | 2 | 6.5 | 2 | 6.3 |

*Results Panel C*


Self-efficacy vs Context Dependency quadrant allocation – teachers (n=31).

| Quadrant | Pre-STEM Academy | Percent of total Pre-STEM Academy | Post-STEM Academy | Percent of total Post-STEM Academy |
|---|---|---|---|---|
| 1 | **10** | 32.3 | **14** | 45.2 |
| 2 | **4** | 12.9 | **13** | 41.9 |
| 3 | **15** | 48.4 | **4** | 12.9 |
| 4 | **2** | 6.5 | **0** | 0 |

**Note: Panel A** shows a scatterplot for pre-service/probationer primary teacher participants mean Anxiety score versus mean Self-efficacy (SE) scores.

**Panel B** shows a scatterplot for pre-service primary teacher participants mean Anxiety score versus mean Enjoyment scores.

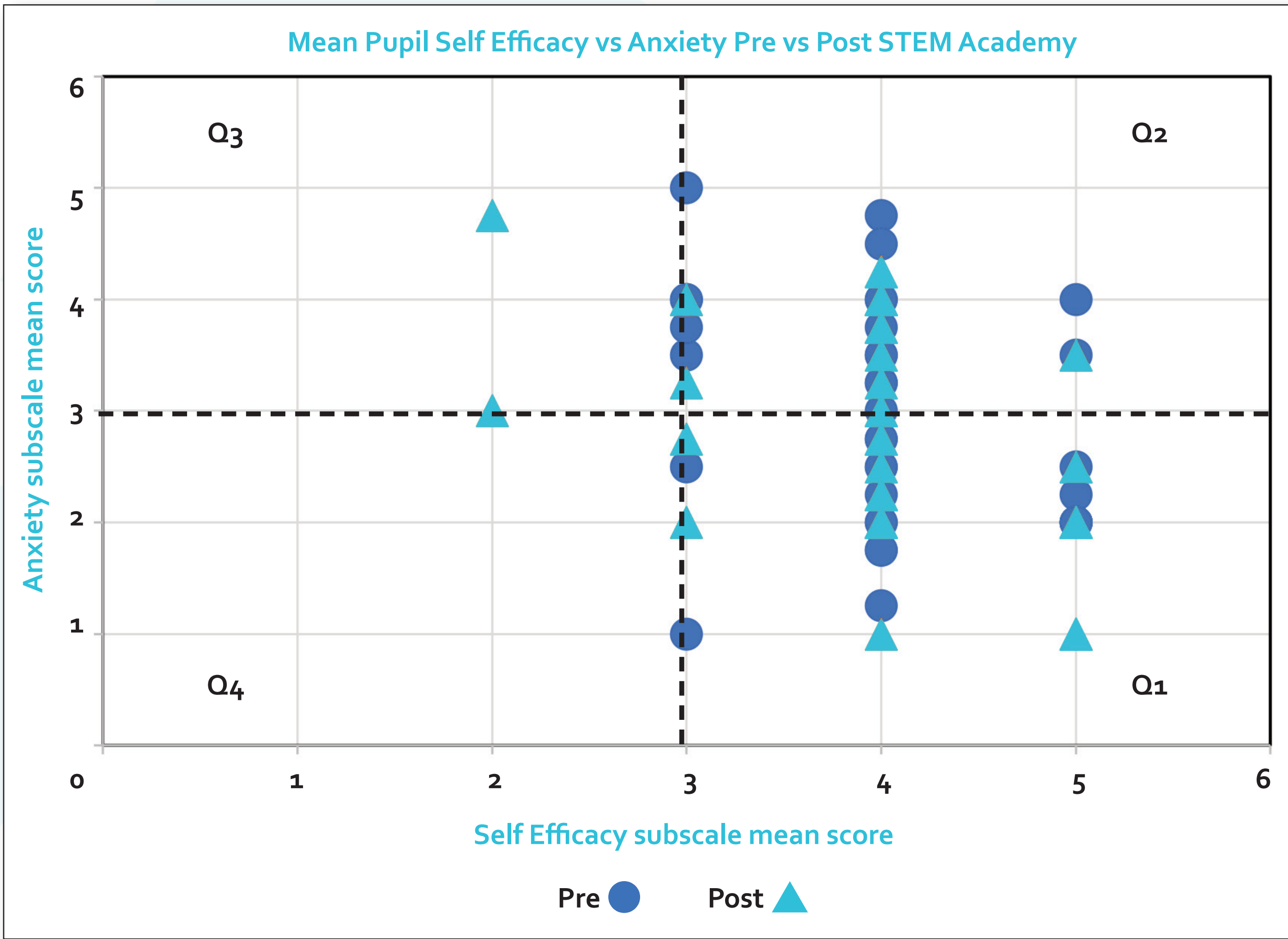
**Panel C** shows a scatterplot of pre-service primary teacher participants mean Perceived Context Dependency (PCD) scores versus Self-efficacy scores. Dashed lines reflect the cut-off point for the quadrants. The quadrants: Q1= High potentials; Q2= Promising; Q3= reluctant; Q4= indifferent. For Panel A, a Self-efficacy (SE) score >3 is quadrants 1 and 2; SE ≤ 3 is quadrants 3 and 4; Anxiety ≥ 3 is quadrants 2 and 3; Anxiety < 3 is quadrants 1 and 4. For Panel B, an Enjoyment score >3 is quadrants 1 and 2; Enjoyment ≤ 3 is quadrants 3 and 4; Anxiety ≥ 3 is quadrants 2 and 3; Anxiety < 3 is quadrants 1 and 4. For Panel C, a Self-efficacy score >3 is quadrants 1 and 2; Self-efficacy ≤ 3 is quadrants 3 and 4; PCD score ≥ 3 is quadrants 2 and 3; PCD < 3 is quadrants 1 and 4.

## Summary table (n=31)

| **Descriptor (teachers %)** | **Affective Control** Self-efficacy vs Anxiety | | **Affective State** Enjoyment vs Anxiety | | **Perceived Control** Self-efficacy vs Context Dependency | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post |
| **High Potential (Q1)** | 22.6 | 74.2 | 35.5 | 68.8 | 32.3 | 45.2 |
| **Promising (Q2)** | 22.6 | 12.9 | 32.3 | 15.6 | 12.9 | 41.9 |
| **Reluctant (Q3)** | 35.5 | 9.7 | 25.8 | 6.3 | 48.4 | 12.9 |
| **Indifferent (Q4)** | 19.4 | 3.2 | 6.5 | 6.3 | 6.5 | 0 |

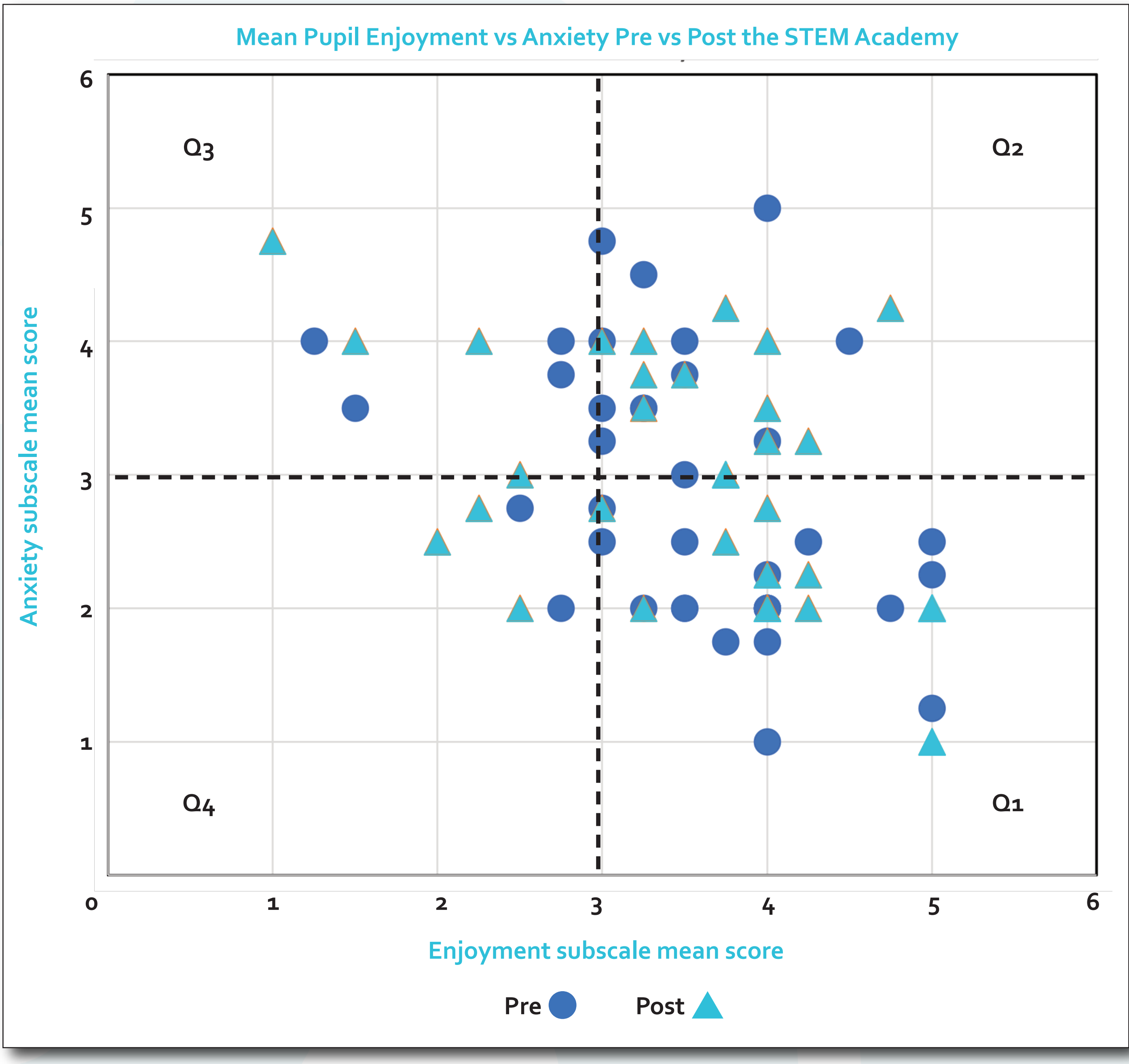
## Summary table for ANOVA results (Key* – highly significant)

| **Descriptor (teachers %)** | **Affective Control** Self-efficacy vs Anxiety | | **Affective State** Enjoyment vs Anxiety | | **Perceived Control** Self-efficacy vs Context Dependency | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post |
| **High Potential (Q1)** | 22.6 | 74.2 p<0.01* | 35.5 | 68.8 p<0.01* | 32.3 | 45.2 p<0.05** |
| **Promising (Q2)** | 22.6 | 12.9 p<0.01* | 32.3 | 15.6 p<0.01* | 12.9 | 41.9 p<0.01* |
| **Reluctant (Q3)** | 35.5 | 9.7 p<0.01* | 25.8 | 6.3 p<0.01* | 48.4 | 12.9 p<0.01* |
| **Indifferent (Q4)** | 19.4 | 3.2 p<0.01* | 6.5 | 6.3 | 6.5 | 0 p<0.01* |




Self-efficacy vs Anxiety quadrant allocation – pupils (n=39).

| Quadrant | Pre-STEM Academy | Percent of total Pre-STEM Academy | Post-STEM Academy | Percent of total Post-STEM Academy |
|---|---|---|---|---|
| 1 | **19** | 48.7 | **20** | 51.3 |
| 2 | **12** | 30.8 | **13** | 33.3 |
| 3 | **5** | 12.8 | **4** | 10.3 |
| 4 | **3** | 7.7 | **2** | 5.1 |




Enjoyment vs Anxiety quadrant allocation – pupils (n=39).

| Quadrant | Pre-STEM Academy | Percent of total Pre-STEM Academy | Post-STEM Academy | Percent of total Post-STEM Academy |
|---|---|---|---|---|
| 1 | **18** | 46.15385 | **18** | 46.15385 |
| 2 | **9** | 23.07692 | **12** | 30.76923 |
| 3 | **8** | 20.51282 | **5** | 12.82051 |
| 4 | **4** | 10.25641 | **4** | 10.25641 |

**Self Efficacy vs Anxiety quadrant allocation – pupils (n=39).**

| Quadrant | Pre-STEM Academy | Percent of total Pre-STEM Academy | Post-STEM Academy | Percent of total Post-STEM Academy |
|---|---|---|---|---|
| 1 | **19** | 48.7 | **20** | 51.3 |
| 2 | **12** | 30.8 | **13** | 33.3 |
| 3 | **5** | 12.8 | **4** | 10.3 |
| 4 | **3** | 7.7 | **2** | 5.1 |

**The results above indicate an increase in the number of teachers and pupils being recorded in quadrant 1 and quadrant 2 and a reduction in the numbers recorded in quadrants 3 and 4 post-participation in the STEM Academy. This is indicative of the positive impact of the STEM Academy on teachers' and pupils' attitudes towards STEM.** Quadrant 1 is indicative of teachers with a high potential in the aspect of engaging in STEM. Quadrant 2 is indicative of teachers showing a promising attitude in engaging in STEM. Quadrant 3 is indicative of teachers who are reluctant to engage in STEM and Quadrant 4 is indicative of teachers who are indifferent in their attitude towards engaging in STEM.

## Samples of pupil and teacher comments post-STEM Academy

**Pupil A:** *'It helped my confidence in meeting new people. Everyone running events were very enthusiastic and knowledgeable so the activities were more engaging. The activities were practical which made them easier to remember.'*

**Pupil B: '***The event had lots of different workshops which were interesting. I learned a lot and got a good overall view in how science is applied in the world of work.'*

**Pupil C:** *'Really brilliant having different groups working in the same room working together.'*

**Pupil D:** *'Possibly make the event a little longer, so as to spend more time in each workshop.'*

**Pupil E:** *'Could maybe identify specific interests in STEM and base group tasks on these so that people engage with their own personal STEM area.'*

**Teacher A:** *'I enjoyed and gained a lot from the 2-day programme, meeting many engaging and inspirational people. It really highlights the importance of making links between research, secondaries, primaries and grass roots and inspiring young children and making the science world accessible as a successful career path.'*

## Data analysis and discussion

Data were analysed using SPSS and the 'R' programme.

A Two-way Friedman ANOVA test was applied to data related to pre-service probationary primary teachers. The resulting analysis of data pre- and post- the STEM Academy demonstrates significant differences in five key components of confidence, namely: self-efficacy, anxiety, difficulty, relevance, and enjoyment.

During analysis of data relating to pupils' attitudes towards science and technology using a Two-way Friedman ANOVA, Wilcoxon Sign Rank test taking into account statements about their relevance in contributing to society and supporting the development of a country, there were significant differences between pre- and post- responses.

Pupil enjoyment versus Anxiety in engagement in STEM showed a positive trend pre- versus post-participation in the STEM Academy. A similar trend was observed in pupil Self-efficacy versus Anxiety pre- versus post-participation in the STEM Academy.

Analysis of the results demonstrate that this multi-level partnership approach to working has a significant impact on teacher confidence in and attitudes towards STEM subjects. For teachers, key components of confidence such as self-efficacy, relevance, anxiety and enjoyment improved significantly.

Overall analysis of the data demonstrated a significant increase in the number of teachers identified as having high potential towards the teaching of science in primary schools. They were also shown to engage more positively in STEM-based activities and their delivery.

The reduction in anxiety and increase in self-efficacy in both teachers and pupils indicate the positive mental health impact (and future application) of this model and approach to improving mental health in teachers and pupils through multi-level partnership working. A recent study reported that making the science more relevant (exactly the aim of the STEM Academy) and more of an adventure had a significant impact on senior pupils' engagement in science (Morgan *et al,* 2022).

Our findings highlight the STEM Academy model of multi-level partnership working as a successful programme for probationer and pre-probationer teachers, especially primary practitioners. It provides primary practitioners with the opportunity to work with secondary pupils and gain an insight into the secondary curriculum and how sciences progress in the secondary school. It also enables primary practitioners to experience working with industry and academia and learn about current developments in both. In doing so, it helps to contextualise STEM learning for teachers and therefore their pupils, in this case primary, and aligns the input of academia and industry with the curriculum to support skills development, inspire learning and demonstrate the relevance of the learning.

Overall, this 'new to the field' approach in co-creation, resulting in the development of workshops involving primary student teachers and, ultimately, primary pupils during the follow-up period is a novel approach to improving primary STEM. Primary pupils would have the opportunity to present their workshop at a future STEM Academy, parents' evening or within a community setting, or using social media. Another strength of the STEM Academy was the emphasis on highlighting the relevance of STEM. The importance of this is discussed by Morgan *et al* (2022).

## Conclusion

The STEM Academy builds partnerships between primary and secondary schools and between primary schools, academia and industry. During follow-up to the STEM Academy, primary probationer teachers will be supported by academic and industrial partners and senior pupils to deliver co-created activities in their primary/secondary school and across the cluster of primaries and local secondaries. Senior pupils will work with academic and industrial partners and deliver co-created activities in secondary schools and modify the activities for delivery in primaries, and to youth groups, at parents' evenings, science festivals, community and fundraising events.

By targeting pupils from deprived areas, with a focus on girls, many children from disadvantaged backgrounds will experience industry for the first time. Through engaging with industry and academia, learning is contextualised and multi-level working will provide an insight into the variety of opportunities that STEM provides. Senior pupils who complete the PRAiSE Award, an award that promotes citizenship and is mapped into teaching standards and professionalism, and primaries who implement co-created activities, will be invited to deliver a workshop at the STEM Academy the following year, therefore assuring the sustainability of the programme. This is a key aspect of the STEM Academy.

The recommendation for primary practitioners is that they should take the opportunity to participate in a STEM Academy. In this way, they will gain more confidence in delivering STEM-based activities within a primary school. They will also develop partnerships with secondary schools where secondary pupils can deliver STEM-based activities within a primary setting. This can support the primary practitioner, as well as excite and motivate primary pupils in STEM. This approach of senior pupils leading STEM workshops in a primary setting has already been used and has been shown to be highly effective in motivating primary pupils in STEM.

The long term aims of the Summer STEM Academy programme are to:

- Build on the success of the STEM Academy and develop the STEM Academy model across more UK ITE institutions;
- Assess impact on teachers and pupils (primary and secondary) during a 6-month and 12-month follow-up regarding engagement in STEM and key components of confidence relating to mental health and transition;
- Extend access to qualified teachers (primary and secondary); and
- Assess the impact of the model on diversity and inclusion. Results of initial data analysis are very promising.

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